

METHODOLOGY

The assessment of hydrocarbon resources is a statistical analysis of geologic data. The principal procedural components of the assessment process consisted of petroleum geological analysis, play definition and analysis, and resource estimation. Petroleum geological analysis provided the geological and geophysical information that was the basis for all other components of the assessment. Play definition and analysis involved identifying and quantifying the necessary elements for the estimation of resources in geologic plays in a form that could be used for statistical resource estimation. The resource-estimation process used a set of computer programs developed for the statistical analysis of play data. The results of that statistical analysis are estimates of the undiscovered conventionally recoverable resources of geologic plays. The resource estimates were further subjected to a separate statistical analysis that incorporated economic and engineering parameters to estimate the undiscovered economically recoverable resources for the assessment areas. For those areas with existing production, estimates of discovered resources were added to estimates of undiscovered conventionally recoverable resources to obtain a measure of total resource endowment.

In order to address recommendations regarding previous MMS assessments³, the MMS adopted a

play-based approach for identification and estimation of resource parameters. A statistical methodology was developed to estimate resources based on these parameters. This section describes the process used by the MMS Pacific Region National Assessment team (hereafter "the assessment team") to analyze the geologic data, identify and evaluate the resource parameters, and develop resource estimates. Because this document is intended primarily as a review of the assessment results, only a brief description of the resource estimation methodology is presented here. A detailed explanation of the general methodology will be provided in a separate document (Pulak K. Ray, oral commun., 1996). This report describes the methodology as applied for the assessment of the Pacific OCS Region. The major procedural steps are shown diagrammatically in figure 2.

In addition to adopting revised geological and statistical methodology and computer programs for this assessment, several public workshops were convened for industry, academia, and other interested parties to discuss MMS geologic interpretations and assumptions used in the assessment process. Additionally, the services of three experts in the fields of petroleum geology and resource assessment were secured to provide technical advice to the assessment team.

PETROLEUM GEOLOGICAL ANALYSIS

The first component of the assessment process involved analysis of the geologic and geophysical data to identify areas of hydrocarbon potential and to ascertain the areal and stratigraphic extent of potential petroleum source rocks, reservoir rocks, and traps within these areas. The information

obtained through this process was the basis for the definition of geologic plays and for the quantification of parameters in the play definition and analysis component. Based on previous assessment experience, assessment areas were defined and grouped within assessment provinces. Individual members of the assessment team were assigned primary responsibility for detailed geological and play analyses of specific assessment areas; however, a team approach was adopted in order to take advantage of the interdisciplinary makeup of the group (geologists, geophysicists, a paleontologist, and a petroleum engineer).

Published and proprietary reports and information were compiled to better understand the depositional and tectonic history of each province and assessment area, to identify the areas of hydrocarbon potential, and to better establish the petroleum geologic framework on which the plays would be defined. The scope of these reports ranged from studies of the regional geology and tectonics of an

³ Following a 1984 MMS assessment of undiscovered OCS resources (Cooke, 1985), a National Research Council (NRC) committee reviewed the MMS resource assessment methodologies and results and recommended certain changes for future assessments (National Research Council, 1986). Similarly, MMS procedures employed in a 1987 assessment (Cooke and Dellagiarino, 1990) were reviewed by a NRC committee and additional recommendations were published (National Research Council, 1991). Additional reviews of the MMS assessment methodologies and reporting procedures were conducted by the Association of American State Geologists, the Energy Information Administration of the U.S. Department of Energy, and the American Petroleum Institute. Following these reviews and the resulting recommendations, MMS embarked on an effort to revise and improve its resource estimation and reporting procedures.

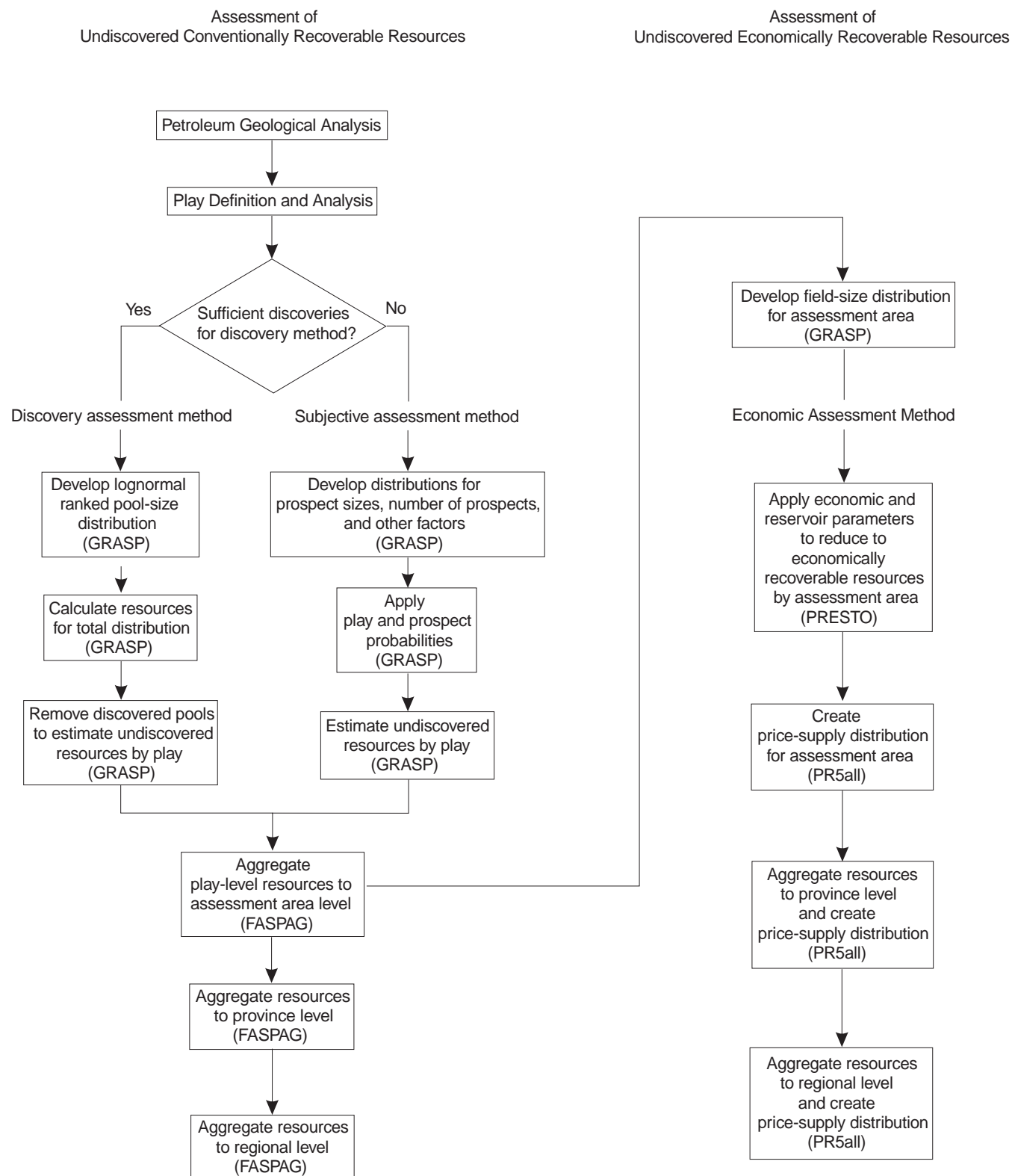


Figure 2. Assessment process flowchart. Boxes represent process or program steps. The diamond represents a decision. Computer programs used to perform steps are shown in parentheses. The left side of the flowchart shows the process for estimating undiscovered conventionally recoverable resources. The right side shows the process for estimating the part of those resources that are economically recoverable.

area to detailed geochemical and well-log analyses from exploratory wells and coreholes. Exploratory well information and interpretations of seismic-reflection profiles were the bases for identifying stratigraphic intervals within the assessment areas. Paleontological and lithological analyses were used to determine the age and environment of deposition of stratigraphic units.

Potential petroleum generative sources were identified through the use of published and proprietary geochemical studies and MMS proprietary data from exploratory and development drilling. Hydrocarbon indications from exploratory and production wells were used along with analyses of well data to identify potential petroleum source rocks and to estimate source-rock properties. Geophysical well information was used along with interpretations of seismic-reflection profiles to estimate generative areas within those source-rock units.

Potential hydrocarbon reservoirs and possible migration pathways from source to reservoir were identified primarily through the use of exploratory well data and interpretations of seismic-reflection profiles. Reservoir-rock properties and the presence

of trapping mechanisms were estimated by using information from well-log analysis and from analogous stratigraphic units in producing areas. Geophysical interpretations of seismic-reflection profiles were used to infer migration pathways and to estimate the extent of stratigraphic intervals in which reservoir-quality rocks are expected.

Identification of potential structural traps (prospects) was based primarily on existing MMS interpretation and subsurface mapping of proprietary seismic-reflection data. Where feasible and appropriate, the interpretations were modified to incorporate new data and ideas. In some areas, interpretations were based on sparse seismic-reflection data, and although those interpretations could be used to identify depositional and structural trends, they could not be used to identify individual prospects. In such cases, and for assessment areas which were outside of areas with existing data or interpretations, estimates of the number and areal size of prospects were based on interpretations from geologically analogous areas. The specific analogs are identified by play in the *Petroleum Geology and Resource Estimates* section of this report.

PLAY DEFINITION AND ANALYSIS

As previously stated, MMS adopted a play-based approach (White and Gehman, 1979; White, 1988; 1992) for the purpose of identifying and estimating resource parameters necessary for the estimation of resources. Play definition involves the identification, delineation, and qualitative description of a body of rocks that potentially contains geologically related hydrocarbon accumulations. As previously stated, a *play* is a group of hydrocarbon accumulations that share a common history of hydrocarbon generation, accumulation, and entrapment. A corollary to this definition is that a group of hydrocarbon accumulations within a properly defined play can be considered as a single entity for statistical evaluation. It is with this understanding that plays were defined for this assessment. Plays were defined based on the determination of source-rock, reservoir-rock, and trap characteristics of stratigraphic units. Individual play definitions were reviewed for consistency by the assessment team. Most plays were defined on the basis of reservoir-rock stratigraphy and were delineated by the extent of the reservoir rocks. A few plays were defined on the basis of structural characteristics of prospective traps. Plays may overlap areally and may in some cases also occupy the same stratigraphic interval (fig. 3).

Play analysis involves the quantitative description

of parameters relating to the volumetric hydrocarbon potential of the play. The presence of necessary conditions for the generation, migration, and entrapment of hydrocarbons is unknown, but probabilities for their existence and quantification can be estimated, and these can then be used in the resource-estimation process to develop probability distributions for quantities of hydrocarbon resources. Play analysis provided the necessary quantitative information in the form of play-specific probability distributions; these distributions reflect the uncertainty about the values of the parameters and were used as the basis for the statistical resource-estimation process.

Each play may be characterized by parameters that, in combination, describe the volumetric resource potential of the play, assuming that the play does contain hydrocarbon accumulations. A range of values was assigned to each parameter, based on information obtained through the petroleum geological analysis component; summaries of the parameters by play are provided in appendix C. Again, a team approach was used to ensure that parameters relating to the likelihood of hydrocarbon occurrence and prospective volumes of hydrocarbon resources were comparable among assessment areas. Some of these values (e.g., areas of mapped prospects

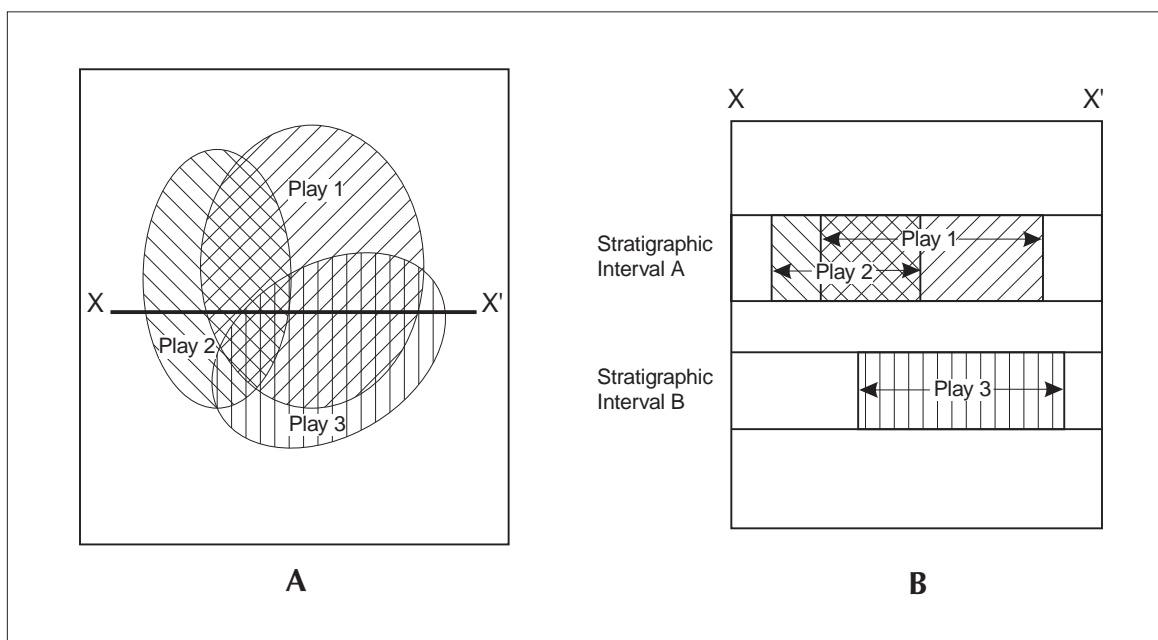


Figure 3. Map-view (A) and cross-sectional (B) representations of three overlapping hypothetical plays. Plays 1 and 2 are within the same stratigraphic interval and overlap areally; play 3 is within a deeper stratigraphic interval.

and thicknesses of expected reservoir-rock units) were based on geophysical mapping. Others (e.g., rock and hydrocarbon properties) were based on exploratory well information. Certain rock and hydrocarbon properties (e.g., net pay, reservoir-rock porosity and permeability, and oil viscosity) are unknown in the absence of exploratory drilling; in such cases, values were based on known properties in areas that are expected to be similar. Where data were insufficient or unavailable, scientifically based subjective judgments were made regarding appropriate geologic analog data that could be used for modeling purposes. The selection of analog data was typically a team decision.

In addition, plays were assigned success probabilities based on discovery status and on a subjective evaluation by the assessment team. Play and prospect probabilities for success were assigned based on a methodology modified from that presented by White (1993). Probability analysis (often called risk analysis) was performed on individual components that are necessary for success of a play or prospect. The probability analysis form used for this assessment is shown in appendix B, along with guidelines for its use. The probabilities (chances) of success of individual components are combined to yield the probability of success for the play as a whole (play chance) and the probability of success for individual prospects within the play (conditional prospect chance). Play chance is the probability that at least one accumulation of conventionally

recoverable resources exists in a play. Conditional prospect chance is the probability that conventionally recoverable resources exist within an individual prospect in the play, given the conditional assumption that the play is successful. Combination of the play chance and conditional prospect chance yields the average prospect chance (including the chance that the play may not be successful).

The components of the probability analysis include the probability of adequate hydrocarbon fill, the probability that reservoir rocks are present and of sufficient quality, and the probability that trapping conditions exist. Each of these components was assigned a value by a qualitative assessment of several elements. Play chance factors were assigned as the probability of adequacy anywhere within the play; the combination of these factors yields the probability that all necessary conditions are present together in at least one location within the play. Prospect chance factors were assigned as the probability of adequacy at an individual prospect; the combination of these factors yields the probability that all necessary conditions are present together at an individual prospect, assuming that the play is successful.

The assessment team used an iterative peer-review process to ensure that probabilities were appropriately assigned among the assessment plays. The resulting probabilities for each of the elements and the combined play and prospect success probabilities are presented in appendix C.

RESOURCE ESTIMATION

Volumetric estimates of undiscovered conventionally recoverable resources and undiscovered economically recoverable resources were based on the geologic and petroleum engineering information developed through petroleum geological analysis and quantified through play analysis. These estimates were developed in two stages. First, undiscovered conventionally recoverable resources were assessed for each play. There was no explicit consideration of resource commodity prices or costs (although there was recognition that current technology is affected by costs and profitability). Then, economic and petroleum engineering factors were included for each assessment area, using a separate methodology, to estimate the portion of these resources that is economically recoverable over a broad range of commodity prices. The following parts of this section describe the main procedural elements of each methodology as used for assessing the resources of the Pacific OCS Region. Several computer programs were used in the resource-estimation process. The use of these programs is indicated diagrammatically in figure 2 and described in the following parts of this section.

ASSESSMENT OF UNDISCOVERED CONVENTIONALLY RECOVERABLE RESOURCES

A probabilistic methodology was developed to estimate undiscovered conventionally recoverable resources based on the resource parameters that

were quantified through play analysis. This included adoption of computer programs developed by the Geological Survey of Canada (GSC) with appropriate modifications to better allow for the simultaneous estimation of oil and gas resources.

Prospect sizes within plays with sufficient data coverage, discovered field sizes within mature basins (those with extensive exploration and production histories), and many other geologic properties have distributions that approximate a statistical pattern called lognormality (figs. 4 and 5). MMS assessment of the volume of conventionally recoverable resources is based on the assumption that, within a properly defined play, the size distribution of the entire population of accumulations (which consists of discovered and undiscovered accumulations) will also be lognormal. This means that in a play with discoveries, the undiscovered accumulations will, in combination with those discoveries, describe a lognormal distribution. Also, in a play with no discoveries, the undiscovered accumulations alone will describe a lognormal distribution.

The concept of lognormal distributions of play parameters was used in the *Petroleum Resource Information Management and Evaluation System* (PETRIMES or PRIMES), a set of computer programs developed by the GSC (Lee and Wang, 1984; 1985; 1990). This play-based approach has an advantage over prospect-based methods in its ability to estimate the size and number of undiscovered accumulations in a play and thus allows for a

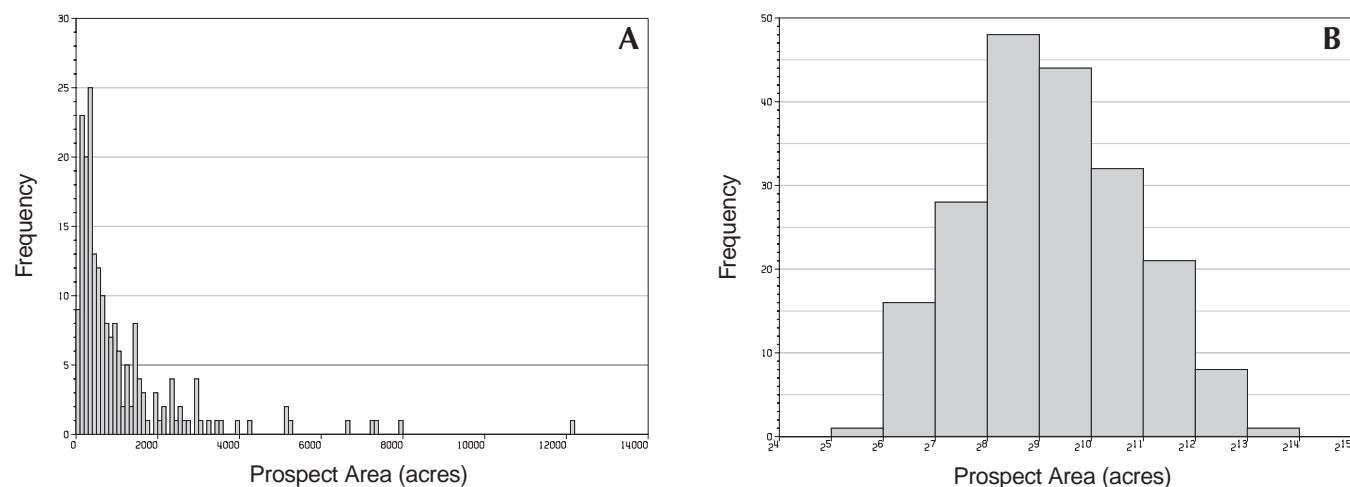


Figure 4. Frequency-versus-size plots of a lognormal distribution. The example shows the areal sizes of mapped prospects in an area where data were sufficient for detailed mapping. The data plot as a skewed distribution when plotted on a linear scale (A). When the data are plotted on a logarithmic scale (B), the approximately normal (bell shape) appearance demonstrates the lognormal nature of the distribution. The example is for 199 mapped prospects in the Monterey Fractured play of the Point Arena Basin assessment area.

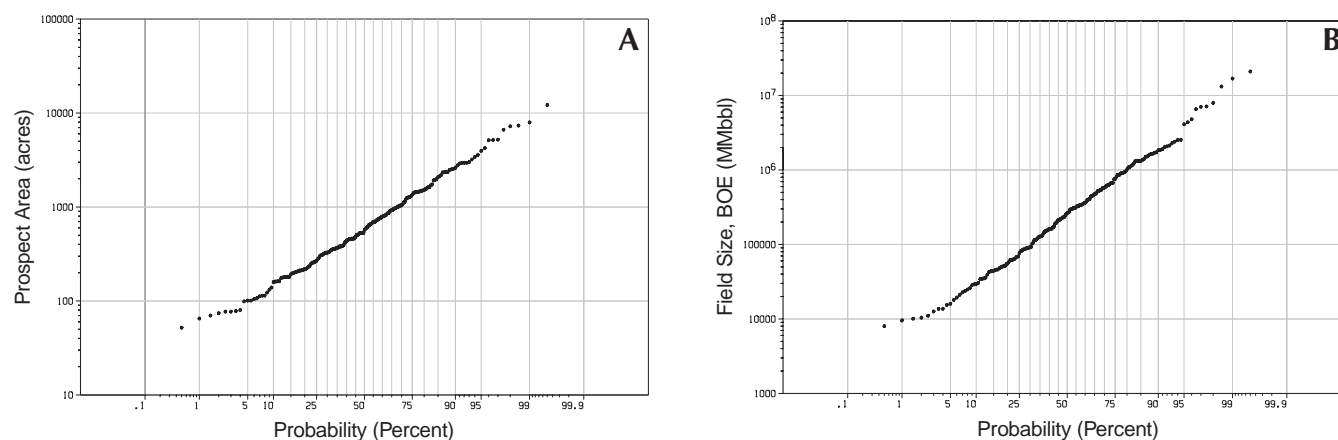


Figure 5. Log-probability plots of lognormal distributions. A logarithmic plot of size versus probability is approximately linear for lognormal size distributions. Figure 5A is a plot of the data shown in figure 4. Figure 5B is a plot of the sizes of 155 fields in the Santa Barbara-Ventura basin proper (onshore and offshore).

better estimation of undiscovered resources. However, PETRIMES was designed for single-commodity plays such as an oil play or a gas play; many OCS plays are mixed plays. MMS adopted the methodology but modified the original PETRIMES to provide for separate estimation of liquid (oil and condensate) and gas (associated and nonassociated gas) hydrocarbon phases in order to better estimate OCS resources. The MMS version of the system is called the *Geologic Resource Assessment Program (GRASP)*. GRASP includes several modules that can be used either for direct modeling of predicted ranked pool-size distributions (*discovery assessment method*), or for modeling of more subjectively derived parameter estimates, which together define the overall volumetric distribution of resources (*subjective assessment method*).

Discovery Assessment Method

The discovery assessment method may be used for plays that have a sufficient number of discovered pools and for which the sizes of those pools are sufficiently well known. Where there are sufficient data, mapped prospect areas approximate lognormality (figs. 4 and 5A). Fields (discoveries) within mature basins generally have size distributions which are lognormal (fig. 5B). If the subset of prospects that contain hydrocarbons is representative (i.e., if there is no statistical bias), the volumes of those accumulations will also be expected to display lognormality. Therefore, the discovered accumulations in a play, when combined with the undiscovered accumulations, will approximate a lognormal distribution.

GRASP provides a computational means to fit the sizes of the discovered pools of a play into a

lognormal distribution, which then represents the entire distribution of pools for the play. Figure 6 is a pool-size rank plot showing the size ranges of pools, which are ranked on the basis of their mean estimated volume of combined oil-equivalent resources. This distribution of discovered and undiscovered pools was developed from the estimated resource volumes of the discovered pools by fitting them within a lognormal distribution. The discovered pools, along with the requirement for approximate lognormality, determine a minimum for the total number of pools in the play; however, lognormal distributions can be defined for a larger number of pools. Therefore, additional information (e.g., prospect mapping) and subjective judgment were employed in order to estimate the total number of pools within the constraints of the data. After development of such a distribution for a play, the undiscovered pools were sampled using Monte Carlo methodology⁴ to estimate the total volume of undiscovered resources in the play.

Subjective Assessment Method

For plays with few or no discoveries, the subjective assessment method was used. In this method, parameter estimates are combined to yield an approximately lognormal ranked size distribution of pools. Measured prospect sizes (e.g., from geophysical prospect mapping) and other parameters were used to estimate pool sizes. If data were sufficient

⁴ The Monte Carlo method is a multiple-trial procedure in which, for each trial, values for constituent parameters are selected at random from their distributions and combined to provide a single result for that trial. The results of many trials compose the overall distribution.

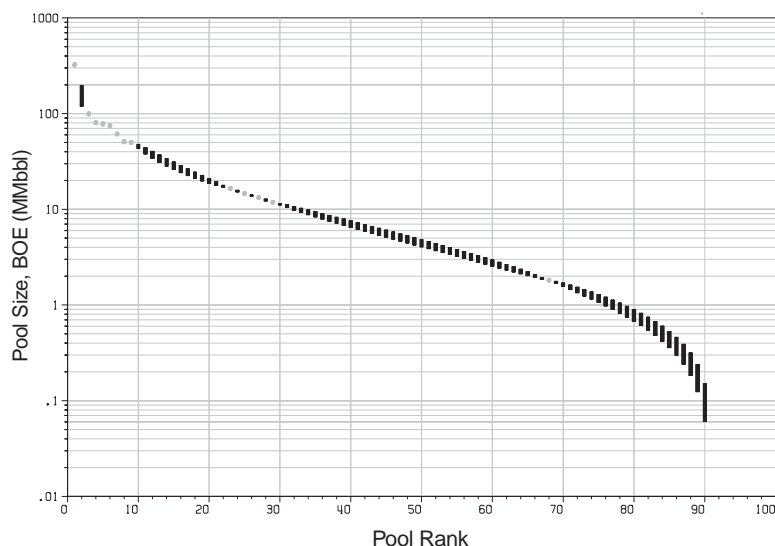


Figure 6. A lognormal pool-size rank plot derived from the discovery assessment method. The total distribution was developed using GRASP by fitting the sizes of discovered pools to a lognormal distribution and using other information to constrain the range for the size and number of pools. The 13 discoveries are shown as gray dots. The black bars represent the 25th- to 75th-percentile size distribution for the undiscovered pools. Ranking is based on resource volume (expressed as barrels of combined oil-equivalent resources). Because the pool distribution is ranked by size, knowledge of the sizes of discovered pools reduces the uncertainty regarding the size of adjacently ranked undiscovered pools (and consequently the height of the corresponding bar) in the plot. The number of pools shown is the predicted total number of pools. The example is for the Monterey Fractured play of the Santa Maria-Partington Basin assessment area.

for detailed mapping, the areal sizes of mapped prospects in the play approximated a lognormal distribution (fig. 4 and 5A). In many assessment areas, prospect mapping is incomplete, so the uncertainty is greater. For plays in such areas, the areal size distribution of the mapped prospects was extrapolated to develop distributions for the areal size and number of prospects in the entire play. Similarly, other parameters (e.g., net pay and recovery factors) were estimated. These estimates were statistically combined to derive a ranked pool-size distribution for the play (fig. 7). The resulting plot is different from that for the discovery method (fig. 6) because it shows the maximum number of pools in the play (fewer pools may actually exist, depending on the probability of occurrence); pool-size rank plots for the discovery method show only those pools whose resource volumes are aggregated to derive play resources. Also, size distributions for individual pools are less tightly constrained. Results of the probability analysis (described in the *Play Definition and Analysis* part of this section) were used to reduce the distribution of prospects (possible pools) to a distribution of pools (containing resources). Monte Carlo methodology was used to statistically combine the various parameters to derive probability distributions for the volume of undiscovered conventionally recoverable resources in the play.

Aggregation of Undiscovered Conventionally Recoverable Resource Estimates

The probability distributions for the volume of undiscovered conventionally recoverable resources in individual plays were aggregated to the assessment area level, then to the province and regional

levels using a computer program called the *Fast Appraisal System for Petroleum Aggregation* (FASPAG) developed by the USGS (Crovelli and Balay, 1988; 1990). This program describes probability distributions in terms of their statistical mean and variance values and uses this information to calculate aggregate resources at the assessment area level (fig. 8).

A few plays in the Pacific OCS Region are partially dependent on some property (e.g., hydrocarbon fill) of another play for their own success; for those dependent plays, their success may be termed a conditional probability. If that property of the independent play has a chance value of less than one, then the success of the dependent play must be reduced for proper aggregation. In all such cases, the property had been determined to be assured (i.e., to have a chance of one), and the play success of the dependent play was fully accounted for during the play-analysis process; therefore, no adjustment was needed during aggregation of resources.

ASSESSMENT OF UNDISCOVERED ECONOMICALLY RECOVERABLE RESOURCES

Following the assessment of undiscovered conventionally recoverable resources and their aggregation to the assessment area level, an economic evaluation was performed using the mean aggregate resource estimate for each assessment area to estimate the portion of those resources that could be extracted profitably over a range of commodity prices, at the present level of technology, and including the effects of current and expected future economic factors. Those factors include costs for exploration, development, and production of resources; market prices

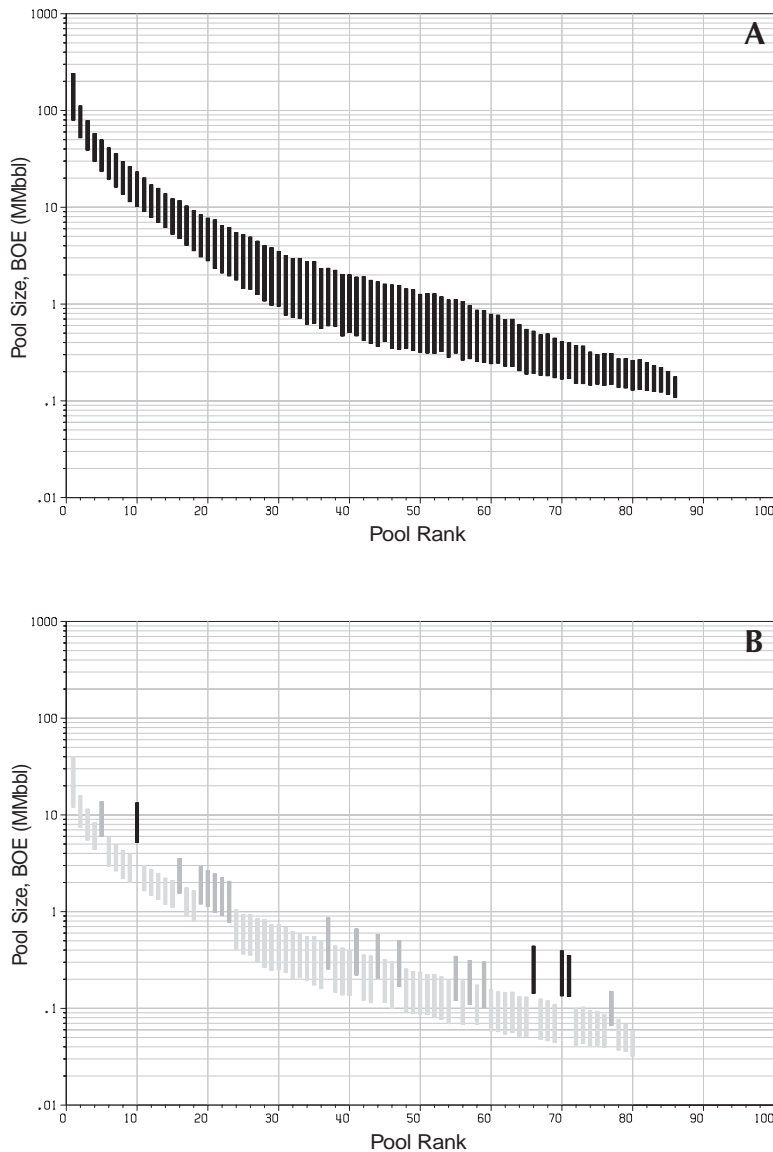


Figure 7. Lognormal pool-size rank plots derived from the subjective assessment method. The bars represent the 25th- to 75th-percentile size distribution for the undiscovered pools. Ranking is based on pool volume (expressed as acre-feet). The range of the size distribution for each pool is much greater than for the pools predicted by the discovery assessment method (fig. 6), indicating a greater uncertainty in predicted pool sizes. The number of pools shown is the maximum number; fewer pools may actually exist, depending on the probability of occurrence. Plots are shown for an oil play (A) and a mixed play (B). Because the ranking is based on pool volume (rather than resource volume) and pools are randomly defined as oil pools, gas pools, or mixed pools (according to their proportional probability), pools in a mixed play do not plot in ranked order on the pool-size rank plot. The oil pools, gas pools, and mixed pools in the example are shown in black, dark gray, and light gray, respectively. Figure 7A is the Monterey Fractured play of the Año Nuevo Basin assessment area. Figure 7B is the Neogene Fan Sandstone play of the Eel River Basin assessment area.

of the various hydrocarbon commodities; and other economic conditions (e.g., interest rates, which affect the cost of capital, and revenues that could alternatively be gained by investing capital elsewhere).

Stacked Plays and Field Sizes

The oil and gas resource totals within each assessment area were the basis for the assessment of economically recoverable resources. Because many of the plays in the Pacific OCS Region are areally superposed (fig. 3), pools in one play may be located near or above or below pools in another play. Such pools are commonly developed as a single field to minimize development costs.

To apply costs appropriately in an economic evaluation, the GRASP discovery assessment method was used as a tool to help create ranked field-size distributions at the assessment area level

in a procedure similar to that used for creating ranked pool-size distributions at the play level. The mean estimates of the combined oil-equivalent resources for the fields together describe a lognormal distribution. These distributions, which consist of discovered fields and predicted undiscovered fields, were developed to be compatible with the combined play-level ranked pool-size distributions. The mean aggregate volume of resources (both oil and gas) for the fields matches the mean aggregate volume of resources of all plays within the assessment area. The number of fields was constrained to be no less than the mean number of pools in any play (corresponding to maximum pool stacking) and no greater than the sum of the means of the number of pools for all plays (minimum pool stacking). Because the fields are considered to be made up of one or more pools from the constituent plays, this

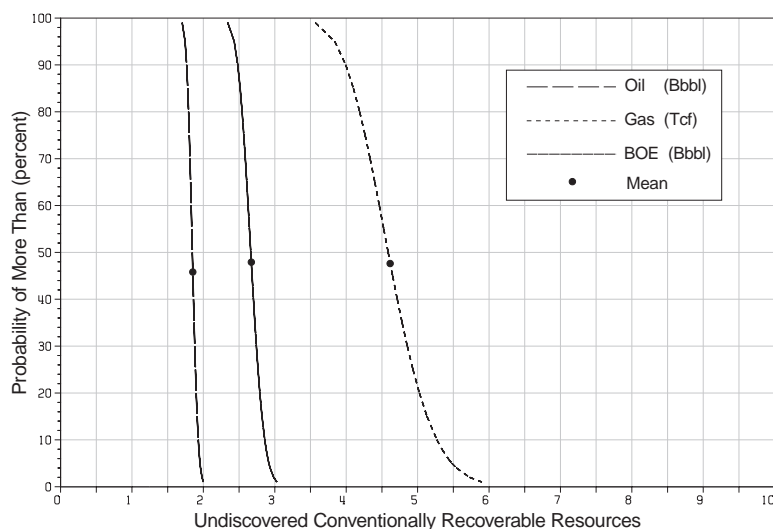


Figure 8. Cumulative probability plot showing distributions for estimated undiscovered conventionally recoverable oil, gas, and combined oil-equivalent resources. The probability value corresponding to a given resource volume indicates the probability of occurrence of that volume or more. The example shows resource distributions for the Santa Barbara-Ventura Basin assessment area.

also placed constraints on the mean field size and the statistical range (minimum to maximum) of the distribution. The resulting distributions are considered to be equivalent—for modeling purposes—to the resource distribution of the assessment area.

Economic Assessment Method

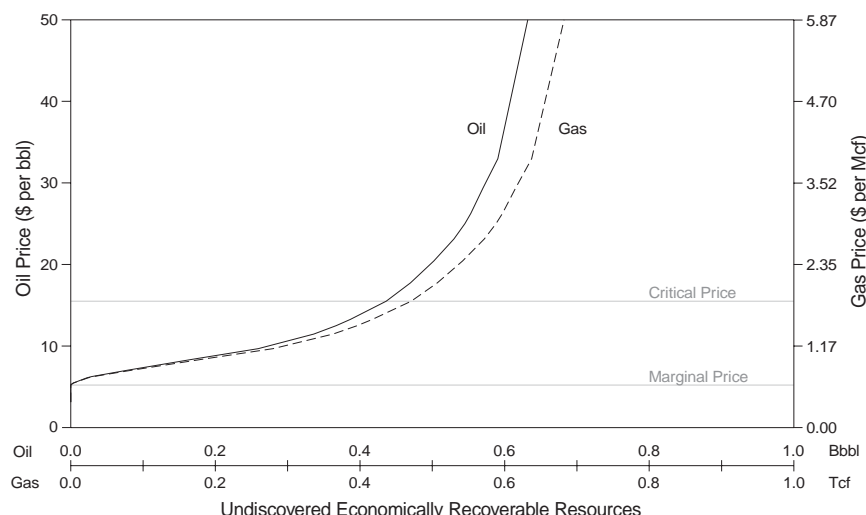
To estimate the portion of undiscovered conventionally recoverable resources that can be profitably extracted given particular economic constraints, MMS developed an enhanced version of its *Probabilistic Resource Estimates Offshore* (PRESTO) program (Cooke, 1985; Cooke and Dellagiarino, 1990). For estimation of undiscovered economically recoverable resources in the Pacific OCS Region, ranked field-size distributions (developed as described above) were input into PRESTO, along with engineering, cost, and economic factors, to reduce the mean undiscovered conventionally recoverable resources to economically recoverable values over a range of commodity prices. Because the ranked field-size distributions were considered equivalent, for modeling purposes, to the combined ranked pool-size distributions of the constituent plays (which include the effects of play and prospect chance), no additional risks were applied.

PRESTO uses Monte Carlo methodology to simulate the exploration, development, production, and delivery of the field resources in each assessment area (fig. 2). The ranked field-size distributions are sampled along with probability distributions for costs, production properties (e.g., gas-to-oil proportion, production rates, and decline rates), and other engineering and economic factors (select data used for the analyses are shown in appendix D). For each field, the program simulates exploration, delineation, installation of production and delivery facilities, and

drilling of development wells. Costs, production, and revenues are scheduled over the lifetime of the field. Each field is modeled separately to determine its individual economic viability—the program develops a risk-weighted discounted cash flow and calculates a present economic value for the field. Then, the economic resources in all fields are combined with additional costs specific to the assessment area to determine its economic resources. Costs for equipment and infrastructure are included at the field level (e.g., platform and production well costs) or assessment area level (e.g., trunk pipeline), as appropriate. This procedure is performed iteratively for varying oil and gas prices to develop a probability distribution of the undiscovered economically recoverable oil and gas resources. The oil price represents the world oil price as defined by the Department of Energy (Energy Information Agency, 1994) and is equivalent to the average refiner's acquisition cost of domestic oil. Local market price variations (e.g., due to varying quality of crude oil or cost of transportation) are accounted for at the assessment area level. The gas price is fixed relative to the oil price at 66 percent of the oil price for equivalent energy content (e.g., an oil price of \$18.00 per bbl corresponds to a gas price of \$2.11 per Mcf).

This assessment allowed for uncertainty in oil and gas prices by developing a continuous series of resource estimates over a wide range of prices; the estimates are portrayed graphically in a *price-supply plot* (fig. 9) for each assessment area, province, and the Region. The price-supply plots (created by an MMS program called PR5all) show the mean volume of resources—both oil and gas—that can be profitably developed, as a function of price. The oil and gas curves on a price-supply plot are linked;

Figure 9. Price-supply plot showing estimated undiscovered economically recoverable oil and gas resources over a range of prices. Because gas prices are tied to oil prices, the individual curves are not independent; the resource values for oil and gas are linked at a given price. The marginal price is the price below which no PRESTO trials were economic within the assessment area. The critical price is the price above which all trials were economic within the assessment area. At intermediate prices, some trials were economic. The example is for the Santa Maria-Partington Basin assessment area.



that is, the supply value of both commodities must be determined together at a given oil price (and its corresponding gas price). This is because the economic viability of an individual field is calculated assuming the presence of both oil and gas together, at a fixed ratio for any given field. Because of this linkage, the oil and gas supply estimates do not reflect relative market-demand effects between the two commodities (i.e., a relative increase or decrease in the market value of gas relative to that of oil is not accounted for in the model).

Aggregation of Undiscovered Economically Recoverable Resource Estimates

The volumetric price-supply estimates of undiscovered economically recoverable resources were derived at the assessment area level for the mean case. These mean estimates were aggregated to the province and regional levels. For tabulated mean values, aggregation was performed by simple arithmetic addition. Aggregation of price-supply distributions and creation of aggregate price-supply plots was performed using PR5all. Because the price-supply plots give only mean values at each price, aggregation was by simple arithmetic addition at each increment of pricing.

ESTIMATION OF TOTAL RESOURCE ENDOWMENT

The total resource endowment, which is the sum of the discovered resources (originally recoverable reserves) and undiscovered conventionally recoverable resources, was estimated for three assessment areas where resources have been discovered. Field-level estimates of originally recoverable reserves (including cumulative production and remaining reserves) in Santa Maria-Partington basin, Santa Barbara-Ventura basin, and Los Angeles basin were tabulated and summed to determine the total volume of discovered resources in each assessment area. The estimate of discovered resources in each assessment area was then added to the mean estimate of undiscovered conventionally recoverable resources to obtain a mean estimate of the total resource endowment in that area. Estimates of discovered resources, undiscovered resources, and total resource endowment were then summed to the province and regional levels.